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ABSTRACT

This overview of recent research on individual differences especially concerns that research which relates to human learning and instruction. Several major areas of research are identified, and within each area various issues related to that area and representative studies are discussed. Whenever possible, references to more comprehensive reviews of the literature are provided. Major emphasis is placed on research investigating performance on psychometric tests in terms of cognitive tasks or processes underlying that performance and on research related to aptitude-treatment interactions. Research on intelligence is also discussed, and reference is made to some of the research on cognitive style, adaptive instruction, and the role of individual differences in learning and cognitive processes. Finally, several issues related to future research on individual differences are discussed. Forty-four bibliographic citations are appended. (Author/GDC)

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CURRENT RESEARCH ON INDIVIDUAL DIFFERENCES IN LEARNING AND INSTRUCTION

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Individual differences have long captured the interest of many people in education and psychology. The various approaches that have been taken to the study of individual differences are many and very diverse. Nevertheless, it would be accurate to say that during the period from approximately 1890 to 1970 research on individual differences, especially as it related to education, was dominated by the psychometric tradition as examplified by the mental test and a methodology based on correlation.

During the past five or ten years, however, there has been a resurgence of interest in individual differences and a dramatic shift in the way educational researchers and cognitive psychologists conceptual and investigate the role of individual differences. Experimental and cognitive psychology, an area which has long ignored individual differences, is finally recognizing that individual differences cannot be ignored if one hopes to have an adequate understanding of psychological processes (e.g., Underwood, 1975). A new approach to research involving mental tests (Carroll, 1976) holds exciting promise for psychometrics, cognitive psychology, and instructional psychology alike. The unification of the correlational and experimental approaches to the study of human behavior that Cronbach (1957) called for over 20 years ago may finally be gaining a foothold in educational and psychological research.

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The purpose of this paper is to review some of the current research on individual differences, especially that research which relates to human learning and instruction. No attempt will be made, however, to provide an exhaustive review of individual studies. Rather several major areas of research will be identified. Within each area various issues and representative studies will be discussed. Whenever possible, references to more comprehensive reviews of the literature will be provided.

Research on Intelligence

The traditional concern for individual differences in intelligence continues to occupy the interest of many investigators, although several new approaches to the study of individual differences in performance on psychometric tests will be discussed in the next section of the paper. Research on intelligence is relevant to the purpose of this paper only to the extent that individual differences in intelligence are related to individual differences in ability to learn in instructional settings. Such an assumption is frequently made (e.g., Hunt, 1976; Snow, 1976a), although the evidence to support the idea that individual differences in intelligence is related to the rate of change in performance (i.e., learning) on various learning tasks is not overwhelming. Nevertheless, the relationship between intelligence and learning has sufficient plausibility for it to be included.

Several recent reviews (Carroll & Maxwell, in press; Horn, 1976, 1977; Nichols, in press) of the more traditional research and issues regarding

intelligence are available. One conception of intelligence that is currently receiving considerable attention is referred to as the hierarchical model (Cattell, 1971; Horn, 1977). This model is relevant to the present paper since it is being used as a conceptual tool in research on aptitude-treatment interactions (to be discussed later in this paper) to help organize the various aptitude processes involved in learning from instruction (Cronbach & Snow, 1977; Shuell, 1978; Snow, 1976a, 1976b).

The hierarchical model postulates several different levels of ability or intelligence. In the American (as contrasted with the British) version the most general level of intelligence ("g") is augmented at a somewhat less general level by fluid intelligence (G_f), crystallized intelligence (G_c), and sometimes a spatial visualization ability (G_v). Below this level in the hierarchy are various abilities of a more specific nature. The distinction between fluid and crystallized intelligence was first formally developed by Cattell (1957).

Briefly, fluid intelligence is viewed as being that aspect of general intelligence that can be diverted into almost any new activity that requires some intelligence to perform. There is often thought to be a general decline in fluid intelligence following adolescence. Crystallized intelligence, on the other hand, is that aspect of intelligence that results from experience--certain abilities commonly acknowledged as requiring or representing intelligence appear to crystallize out of the experiences that an individual has during his lifetime--and there is a general increase in crystallized intelligence throughout most of a person's lifetime. The

interested reader is referred to Cattell (1971) and Horn (1977) for a more complete description of the theory.

A variety of different approaches to the study of intelligence, especially those that reflect the combination of the experimental and correlational approaches to the study of intelligence, are presented in a book edited by Resnick (1976). One very promising new approach to the study of intelligence and other abilities represented by performance on various psychometric tests is characterized by an attempt to determine the psychological processes responsible for individual differences in performance on those tests.

Psychometric Tests and Cognitive Tasks

During recent years both cognitive psychologists and psychometricians have become increasingly interested in determining the relationship between performance on various psychometric tests and performance on various types of cognitive learning tasks. The perspective here is to view cognitive tasks and learning tasks as comparable to psychometric tests in that performance in both types of situations require the use of various cognitive processes. The main concern is to understand the cognitive processes required for performance on these tests.

For example, Estes (1974) undertook to analyze various aspects of standard intelligence tests in terms of concepts from cognitive learning

theory, and he discussed the results of various studies that are consistent with such an analysis. Likewise, Carroll (1976) analyzed the various psychometric tests in the Educational Testing Service's Kit of Reference Tests in terms of the cognitive processes required for performance on the various tests. While the analysis is still logical in nature, it respresents a major step in trying to develop an integrated understanding of individual differences in performance.

The work of Earl Hunt and his associates (e.g., Hunt, Frost, & Lunneborg, 1973; Hunt, Lunneborg, & Lewis, 1975) provided the beginning of an empirical data base for this type of analysis. Hunt's general procedure was to take college students who score high and low on an intelligence test (both verbal and quantitative tests have been used) and then see to what extent the performance of the two groups differ on a variety of different cognitive learning tasks--for the most part well established laboratory-type tasks.

For example, a task developed by Michael Posner and his associates (Posner, Boies, Eichelman, & Taylor, 1969; Posner & Mitchell, 1967) has been used extensively in cognitive psychology to measure the amount of time required by subjects to access overlearned information in long-term memory. The task consists of presenting two letters to the subject, and the subject's task is to indicate whether the two letters are the same or different by pressing one of two keys. Two different types of instructions are provided to the subject on different parts of the task; precautions are

taken to ensure that the subject knows on what basis he or she is to respond.

Under the physical identity (PI) instructions the subject is to respond "same" if the two letters that are presented are of the same physical configuration (e.g., AA, bb, etc.) and respond "different" if they are not (e.g., Aa, AB, etc.). Presumably, it is not necessary for the subject to access any verbal codes in order to perform the task. For the name identify (NI) instructions, the subject is to respond "same" if the two letters have the same name even though they may have different physical characteristics (e.g., Aa) and respond "different" if the two letters do not have the same name. In order to perform this task the subject must presumably access the verbal code in long-term memory for the letters that are presented. Thus, the difference in the subject's reaction time on the two different tasks provides an index of how long it takes him or her to access verbal information in long-term memory.

University students who are in the lower quartile on a standard verbal intelligence test take about 40% longer to access this information than students in the upper quartile on the same test (Hunt, Frost, & Lunneborg, 1973; Hunt, Lunneborg, & Lewis, 1975). Ten-year-old children take about three times as long as the high verbal university student while children who are mildly mentally retarded take about five times as long as the high verbal university students (Hunt, 1978), although in the latter case at least some question can be raised as to how well the verbal labels have been learned.

Other investigators (e.g., Jensen, 1978; Keating & Bobbitt, 1978) have also studied the relationship between reaction time and performance on intelligence. In general, there appears to be a reasonably strong correspondence between individual differences in reaction time and individual differences in performance on intelligence tests. The exact way in which this relationship should be interpreted is not always clear. Most psychologists would not interpret it in terms of physiological differences in speed of neural transmission, although that possibility cannot be ruled out completely. Rather, reaction time is usually taken as an index of either the number of mental operations that must be carried out in performing a task or the ease with which individuals can perform tasks of varying degrees of complexity.

A related approach for investigating the relationship between performance on psychometric tests and more complex cognitive tasks has been developed by R. Sternberg (1977b). This approach is known as componential analysis and involves analyzing a complex task (which might be a test item) in terms of the components involved in performing the task and the rules used for combining the components. For example, in solving the analogy A:B::C:D, four components might be identified. An estimate of how much time is required to perform the last component of the task is obtained by allowing an individual as much time as desired to study the A:B::C part of the analogy. When he or she indicates that they fully understand that part of the analogy, the complete analogy is presented and the time required to indicate the appropriate answer is recorded. Scores representing individual differences on each component can then be related to one another and to

other batteries of individual difference measures. Likewise, mathematical models of the components involved in performing a complex mental task can be compared with the data obtained to determine which model best fits the data. This procedure has been used to investigate both inductive analogical reasoning (Sternberg, 1977a, 1977b) and deductive reasoning (Sternberg, in press).

While this type of analysis and investigation of the relationship between individual differences in performance on psychometric tests and individual differences in performance on cognitive tasks is just beginning, it appears to hold considerable promise for helping us to better understand the role of individual differences in learning from instruction.

Aptitude-Treatment Interactions

For many years educational research seemed to be predicated on the notion that there was a single best instructional method that could be used for every student. It is now recognized that different instructional treatments may be optimal for maximizing the performance of students with different characteristics. Thus, Treatment A may result in a high level of performance for one group of learners (e.g., those who score high on a particular aptitude test) and in a low level of performance for another group of learners (e.g., those who score low on the same aptitude test). Treatment B, on the other hand, may result in just the opposite results (low performance for those who score high on the aptitude and high performance

for those who score low on the aptitude). In such a case an interaction is said to occur between the aptitude and the two instructional treatments. Methodologically, the aptitude-treatment interaction (ATI) paradigm was the product of Cronbach's (1957) call for the unification of the correlational and experimental approaches to the study of behavior. Regression analysis is typically used to compare the slopes of regression lines (performance on one or more aptitudes) for two different experimental treatments. Statistical tests for parallelism of regression lines are used to isolate interactions between the experimental treatments and the aptitude(s) being studied. The major reference for research in this area is the recently published handbook by Cronbach and Snow (1977).

An aptitude is simply a hypothetical construct used to characterize individual differences that will predict performance in some situation, usually academic. Traditionally, aptitude has been thought of in terms of "intelligence" or "scholastic ability," although such a narrow conception is unnecessarily limiting (Snow, 1976a). Cronbach and Snow (1977) intentionally defined aptitude in a very broad manner as "any characteristic of a person that forecasts his probability of success under a given treatment" (p. 6). Such a broad definition is desirable given the relatively early stage of development of ATI research. Any stable characteristic such as cognitive style, personality, motivation, interest, prior achievement, or special ability for which a demonstrable relationship with learning can be established should thus be considered as a viable aptitude. As research continues, it will become increasingly important for us to develop a theoretical as well as an empirical understanding of those

individual differences in aptitude that can be shown to be important in determining performance under different instructional treatments.

Research on ATIs has mushroomed during the past decade, a period of time that rather accurately reflects the existence of the field. It is somewhat difficult to summarize the various findings since the studies are rather diverse and since many of the early hypotheses on the type of aptitudes (e.g., visual vs. verbal ability) that many investigators thought would enter into ATIs in a rather straightforward manner proved to be either too simple minded in their conception or just plain inappropriate. Nevertheless, it is clear that ATIs exist, and several excellent reviews (Cronbach & Snow, 1977; Snow, 1976a) of the current state-of-the-art have appeared in the last couple of years.

The most useful heuristic for summarizing the current findings is probably the concern for aptitude complexes as developed by Dick Snow (Cronbach & Snow, 1977; Snow, 1976a, 1976b). Two complexes have been suggested as being of interest to further research. The first one involves intellectual factors relating to various aspects of intelligence. This complex is referred to as the $G_c G_f G_v$ complex and consists of fluid-analytic intelligence (G_f), crystallized-verbal intelligence (G_c), and spatial visualization ability (G_v). A hierarchical model is suggested, and Snow (1976a, 1976b) has reported several studies done within this framework. The most interesting and persisting finding at this time regarding the $G_c G_f G_v$ complex, although even this finding should be taken with a certain amount of

tentativeness, has to do with the information-processing burden that a given instructional treatment demands of the learner.

Imagine for a moment an instructional treatment that provides little explicit structure for the students; in order for students to learn from the instruction being provided they must puzzle things out for themselves, develop their own organization for the material being presented, and develop their own integrations and understandings of the material since little of this type of thing is provided by the instructional treatment. Now imagine a second instructional treatment in which a fair amount of structure and organization of the material is provided in an explicit manner by the instruction. Students are not required to figure out for themselves what is expected of them or how the material can be organized and integrated in a manner that will result in optimal performance; this type of instructional support is provided by the instructional treatment being utilized. Now, the interesting question for our purpose here is whether or not these rather different instructional treatments will have differential effects for different types of students.

Students who score high on the intellectual aptitude complex tend to do best with the type of instructional treatment that requires them to do their own information processing. When the more structured treatment is used, the performance of these high ability students is equivalent to or even slightly inferior to the performance of the low ability students. Presumably, providing structure and directions for learning to students who are already able to do this effectively can interfere with or prove to be less effective

than what these students can do for themselves. For the low ability students, however, the pattern is just the reverse; they do best with the more structured instructional treatment that places less of a burden on their information-processing capabilities (Snow, 1976a).

The second aptitude complex is concerned with personality factors that seem to be consistently related to learning. Cronbach and Snow (1977) refer to this general construct in terms of "constructive" vs. "defensive" motivation. This aptitude complex, referred to as $A_i A_c A_x$ is comprised of individual differences in anxiety (A_x), achievement via independence (A_i) and achievement via conformity (A_c).

Several studies (Domino, 1968, 1971, 1974; Dowaliby & Schumer, 1973; Peterson, 1977) indicate that students learn best when they are matched with a teacher who either shares the same personal preferences toward learning or encourages the type of orientation or activities that are consistent with the students' predispositions. For example, students high in achievement via independence and low in achievement via conformity did best with instructors whose teaching style encouraged the students to be independent and to take a more active, participative role in learning for the course. On the other hand, students high in achievement via conformity and low in achievement via independence learned the most when the teaching style of the instructor required conformity, provided more structure in terms of the activities for the course and was, in general, more controlling in terms of what went on in the course and the activities in which the students engaged.

Aptitudes can be characterized in a variety of different ways, and it is clear that several different types of aptitudes can interact with instructional treatments. Individual differences in the knowledge that a person brings with them to an instructional situation (i.e., prior achievement) is clearly one important type of aptitude that must be considered (Tobias, 1976, 1978). These achievement-treatment interactions can occur even when intelligence is controlled (Tobias & Ingber, 1976). In addition, individual differences in the psychological processes responsible for learning are also important (Shuell, 1978, in press). Some of these processes or information-processing strategies may be, for all practical purposes, permanent while others may be learned and hence potentially trainable. Thus, it may be possible to modify or train certain types of aptitudes for learning once these have been identified. That is, if effective strategies for learning in certain situations are known, then these strategies and their corresponding aptitudes can serve as appropriate outcomes as well as predictors. If certain aptitudes are modifiable, we must carefully monitor them during learning since the ATIs represented by them are likely to change during the course of learning.

In general, ATI research has two purposes, although these purposes overlap to a considerable degree. First, ATI research can help us to better understand on a theoretical level those psychological processes involved in learning from instruction. Second, information obtained from ATI research may one day assist us in making practical decisions that will improve the quality of the education received by all students. There are several ways in which this practical application might occur, but it must be realized

that ATI research is not presently ready for implementation. Field research in operational settings is presently needed, but these programs should reflect the spirit of research including the tentativeness of conclusions and the continual evaluation of the instructional program.

There are several ways in which viable ATI findings may be used to improve the educational experience received by students. One is to provide appropriate matches between various instructional treatments and different types of students. Although several different types of matches have been identified (Cronbach & Snow, 1977; Messick, 1976), the problem of finding an appropriate match is extremely complex (Shuell, in press) and anything even approaching a workable system is presently lacking.

Other Areas of Research

Several areas of research on individual differences are so closely related to learning and instruction that some mention must be made of them in any attempt to review the current literature in this general area. While the flavor of research in these areas is somewhat different from that encountered in the preceding sections of this paper, it is rather easy for one to get the feeling that many of the same basic issues are being addressed. While it is impossible to adequately develop these areas within the time and space limitations of the present paper, good reviews are

available of the current research in each of the three areas to be mentioned.

The first of these areas is concerned with cognitive style. Cognitive style refers to preferred ways different individuals have for processing and organizing information and for responding to environmental stimuli. This area presents some interesting possibilities for the eventual integration of the personality and cognitive aspects of individual differences, although considerable effort is still required before any meaningful integration is likely to be achieved. The research associated with five major approaches to cognitive style--authoritarianism, dogmatism, cognitive complexity, integrative complexity, and field dependence/independence--was recently reviewed in a book by Goldstein and Blackman (1978). In addition, an article by Goodenough (1976) reviews research on field independence/dependence related to learning and memory, and the educational implications of this cognitive style variable are discussed by Witkin, Moore, Goodenough, and Cox (1977).

Another area is the growing concern for investigating the role of individual differences in learning and cognitive processes. After years of ignoring and trying to minimize the effects of individual differences, some experimental and cognitive psychologists have gradually begun to acknowledge their existence and to realize their importance in trying to understand human behavior (Melton, 1967; Underwood, 1975). A symposium on individual differences related to learning, reported in a book edited by Robert Gagné (1967), became a milestone for research on individual differences. More

recently, Snow (1976a, 1976b) has called for the development of a laboratory science on individual differences in aptitude tests, learning tasks and the corresponding ATI constructs. These two articles also review much of the contemporary research in this area.

The third area to be mentioned is concerned with research and development aimed at tailoring instruction to fit the needs of individual students. Several major attempts have been made to develop operational systems of individualized instruction. A book edited by Talmage (1975) discusses several of these systems. Mastery learning and the Personalized System of Instruction (PSI or the Keller Plan) represents another major approach, and most of the research associated with these latter two systems has been reviewed by Block and Burns (1976).

General Concerns for Future Research

Certain issues pose a challenge for future research on individual differences related to learning and instruction. One of these issues has to do with the way we choose to define or conceptualize individual differences. Differences among individuals are virtually limitless. Since it is possible to define or describe these differences in a variety of different ways, some consideration needs to be given to how this might be done in order for us to be able to make the most sense out of the many different ways to collect data on individual differences. What is needed is a systematic way for

representing individual differences. The way one goes about this task should depend on the purpose they have for studying individual differences.

Over the years individual differences have been conceptualized and defined in many different ways for a variety of different purposes. Definitions in terms of types, traits, abilities, and performance on psychometric tests have been used for purposes of simple description, prediction of future performance, and in some cases theoretical understanding. Viable taxonomies need to be developed--not for the sake of simply classifying individuals (that has been tried with little success) but for the purpose of guiding our research efforts. Criteria need to be developed that will permit us to determine which individual differences are important and which ones are trivial.

We sometimes overlook the fact that individual differences as we usually think of them do not exist for a single individual. Rather they are conceptions that permit us to characterize differences among individuals. Group differences (i.e., sex differences, race differences, etc.) provide an example of what is involved. But for what purpose have these conceptions been developed? The way we choose to characterize individual differences may or may not have important consequences in terms of what we are interested in studying when we pursue individual differences in learning and instruction. Developmental differences provide a counter example to what is involved when one considers individual differences and group differences. By developmental differences I do not mean cross sectional differences for different chronological ages--these are basically group differences--but

rather sequential differences that occur within a given individual as he or she experiences different factors or instructional treatments. Some serious consideration needs to be given to the relationship between individual differences and developmental differences and how they might be integrated into a single conceptual system.

There is actually something of a dilemma involved in doing research on individual differences. If one conceives of a continuum along which the similarity among individuals can be specified, then the problem arises as to the appropriate points or boundaries that can be used to reliably and validly describe the differences that exist among individuals. At one extreme is the possibility that all individuals are basically the same and that general laws can be discovered that apply to all individuals. This is the orientation that experimental psychologists followed for years and which we now acknowledge as being extremely short sighted. At the other extreme is a basically idiographic orientation that states that every individual is unique and that general laws are not possible. Any approach that wants to develop a systematic body of knowledge about individual differences must take a position somewhere between these two extremes, but such a position by its very nature is rather artificial and arbitrary. Nevertheless, we must find ways to characterize differences among individuals that are useful for the research purpose we are interested in pursuing. To keep these limitations in mind can only help to make that research more fruitful.

What is needed then, at least in part, is to develop new types of aptitudes (Glaser, 1972) and their corresponding measures. These new

aptitudes need to reflect what is currently known about the processes involved in learning from instruction (Shuell, 1978; Snow, 1976a). Nearly all of the current research on individual differences utilize psychometric tests that come more-or-less off the shelf. Consequently, aptitudes and the corresponding research questions are usually determined by preexisting tests regardless of their appropriateness. These preexisting tests were not developed with specific instructional methods or specific learning processes in mind, and thus it should not be surprising if they prove to be limited in situations for which they were not designed.

It may be necessary to work backwards, so-to-speak, and develop new psychometric measures of aptitudes designed to differentially predict performance in different instructional settings. This would mean selecting instructional methods or settings that might plausibly require different types of abilities or aptitudes in order to perform well in the different situations and for which there is some plausibility that individuals possess these abilities or aptitudes to differenting degrees. For example, there is a reasonable amount of intuitive feeling among educational researchers and psychologists that ATIs should exist for instructional methods that require either visual or verbal modes of processing information. Most of the ATI research investigating this possibility of visual-verbal ATIs, however, have failed to find any substantial effects for this factor (Cronbach & Snow, 1977; Snow, 1976a).

While there may be a number of reasons for this failure to find the expected ATIs, including the possibility that individual differences in

these aptitudes just do not interact with different instructional methods. One possibility, however, that may be worth pursuing further is that the measures we have of visual aptitudes and verbal aptitudes may not be valid or may be inappropriate for the instructional situations we are investigating. Thus, one way one might profitably pursue this problem further is to develop new measures of visual and verbal aptitudes that will differentially predict performance in instructional settings that require visual processing and those that require verbal processing of information. To do this, one would begin by selecting instructional procedures or a series of instructional settings for which some agreement could be obtained that the methods in question require either visual or verbal processing of information. Then, rather than selecting preexisting tests to do ATI studies, one would develop an item pool to be given to subjects before they participated in the selected instructional treatments. Items then would be selected from the pool that differentially predicted performance in the two settings. Further validation studies, of course, would be required, but if items could be found that would differentiate between verbal aptitudes and visual aptitudes, then there is at least a possibility that ATIs exist for these types of individual differences.

Some concern should always be given to the context in which research on a given topic is conducted. This is especially true when different criteria for validation and different theoretical assumptions are involved. Such is the case with research on individual differences. Times are changing, and along with that change there has been a change in the social meliu and social assumptions that supported and helped to validate the traditional

psychometric approach to the study of individual differences. Many of the criteria used in traditional psychometric research are seen by many researchers to be no longer viable or to be viable only in a much more limited sense. The Darwinian concept of survival of the fittest is giving way in many quarters to a more egalitarian concept that education should help facilitate the achievement of every individual to his or her maximum potential. Research on individual differences need to examine the significance of this change, especially as it relates to research on educational problems. It should be realized, however, that from a scientific viewpoint one approach is not wrong while the other is right. Both can add to our knowledge of individual differences. Realization of how the two approaches differ, however, provides part of the interesting challenge awaiting those researchers who will be investigating individual differences in learning and instruction.

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